PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

Date of mailing: 23 September 1999 (23.09.99)	
International application No.: PCT/SG98/00020	Applicant's or agent's file reference: FP1046
International filing date: 18 March 1998 (18.03.98)	Priority date:
Applicant: BAO, Feng et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International preliminary Examining Authority on:

31 August 1999 (31.08.99)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was [ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer: J. Zahra Telephone No.: (41-22) 338.83.38

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference FP 1046	**FOR FURTHER ACTION** See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/SG 98/00020	International filing date (*day/month/year*) 18 March 1998 (18.03.98)	Priority Date (*day/month/year*)
International Patent Classification (IPC) or national classification and IPC IPC^6: H 04 L 9/32		
Applicant Institute of Systems and Science et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examination Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of ______ sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand 31 August 1999 (31.08.99)	Date of completion of this report 27 December 1999 (27.12.99)
Name and mailing address of the IPEA/AT Austrian Patent Office Kohlmarkt 8-10 A-1014 Vienna Facsimile No. 1/53424/200	Authorized officer Hajos Telephone No. 1/53424/410

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

I. Basis of the report

1. With regard to the **elements** of the international application:*

☒ the international application as originally filed

☐ the description:
pages ______________________, as originally filed
pages ______________________, filed with the demand
pages ______________________, filed with the letter of ______________________.

☐ the claims:
pages ______________________, as originally filed
pages ______________________, as amended (together with any statement) under Article 19
pages ______________________, filed with the demand
pages ______________________, filed with the letter of ______________________.

☐ the drawings:
pages ______________________, as originally filed
pages ______________________, filed with the demand
pages ______________________, filed with the letter of ______________________.

☐ the sequence listing part of the description:
pages ______________________, as originally filed
pages ______________________, filed with the demand
pages ______________________, filed with the letter of ______________________.

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language ______________ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages ______________.

☐ the claims, Nos. ______________.

☐ the drawings, sheets/fig ______________.

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as „originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT	International application No. PCT/SG 98/00020

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

   ☐ restricted the claims.

   ☐ paid additional fees.

   ☐ paid additional fees under protest.

   ☐ neither restricted nor paid additional fees.

2. ☐ This Authority found that the requirements of unity of invention is not complied with and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirements of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

   ☒ complied with.

   ☐ not complied with for the following reasons:

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

   ☐ all parts.

   ☐ the parts relating to claims Nos.

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Citations and explanations

The cited documents show the use of digital signatures in public key cryptographic systems for verifying the integrity and origin of digital messages. The digital signature algorithms may also be used to prove to a third party that the message was signed by the actual originator.
However none of the cited documents disclose the relevant feature of claim 1 that the third party is decrypting the encrypted first digital data to obtain the first digital data, verifying that the first and the second digital data are valid and, if both the first and the second digital data are verified as valid, sending the first digital data to the second party and the second digital data to the first party.

Therefore, the subject-matter of claim 1 and the dependent claims 2-7 can be considered novel and involving an inventive step.

Industrial applicability is given for all claims.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-7	YES
	Claims		NO
Inventive step (IS)	Claims	1-7	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-7	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

The following documents are cited in the Search Report:

EP 0 328 232 A2
WO 96/02993 A2
EP 0 578 059 A1
WO 93/03562 A1

EP 0 328 232 A2 describes a public key cryptographic system with digital signature certification which authenticates the identity of the public key holder. A hierarchy of nested certifications and signatures are employed which indicate the authority and responsability levels of the individual whose signature is being certified. Countersignature and joint signature requirements are referenced in each digital certification to permit business transactions to take place electronically.

WO 96/02993 A2 discloses a system for securely using digital signatures in a public key cryptographic system that alows security policy and authorization requirements. Each user is associated with a pair of keys, namely a public key and a private key. The digital signatures are formed using encryption algorithms. These digital signatures provide origin authentification, because only the holder of the key used for validation of the signature could have signed the message and non-repudiation, as irrevocable proof to a third party that only the signer could have created the signature.

EP 0 578 059 A1 shows Guillou-Quisquater type digital signature schemes.

WO 93/03562 A1 describes digital signature algorithms for verifying the integrity and the origin of a message. To use the digital signature algorithm effectively, means of associating a public and a private key pair with each signer are provided. These known digital signature algorithms may also be used to prove to a third party that the message was signed by the actual originator.

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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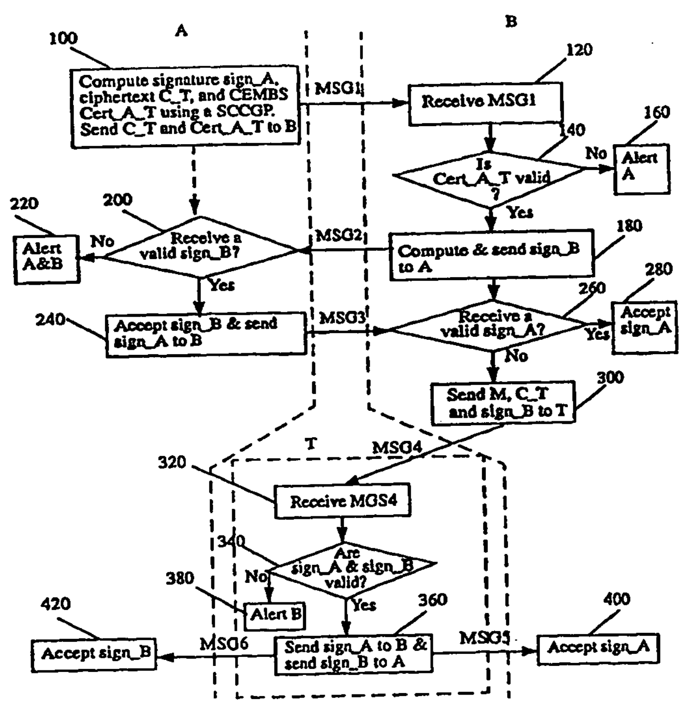
Published
With international search report.

(54) Title: A METHOD OF EXCHANGING DIGITAL DATA

(57) Abstract



A method of exchanging digital signatures (sign_A, sign_B) between a first and a second party (A, B) includes the first party (A) encrypting their signature (sign_A) and generating an authentication certificate (Cert_A), the authentication certificate (Cert_A) authenticating that the encrypted signature (C_T) is an encryption of the signature (sign_A). The first party (A) sends the encrypted signature (C_T) and the authentication certificate (Cert_A) to the second part (B). The second party (B) verifies that the encrypted signature (C_T) is an encryption of the digital signature (sign_A) of the first party (A), and if the verification is positive, the second party (B) sends its digital signature (sign_B) to the first party (A). The first party (A) verifies that the digital signature (sign_B) is the digital signature of the second party (B), and if the verification is positive the first party sends its unencrypted signature (sign_A) to the second party (B). The second party (B) verifies that the digital signature (sign_A) is the first party's digital signature, and accepts the digital signature (sign_A) if the verification is positive. If the verification is negative, the second party (B) sends the encrypted digital signature (C_T) and its digital signature (sign_B) to a third party (T). The third party (T) is independent of the first and second parties (A, B) and has a decryption key to decrypt the encrypted digital signature (C_T) of the first party (A). The third party (T) decrypts the encrypted digital signature (C_T) to obtain the first party's digital signature (sign_A), and verifies that the digital signatures (sign_A, sign_B) are the digital signatures of the first and second party (A, B) respectively. If both digital signatures (sign_A, sign_B) are verified as the digital signatures of the first and second parties (A, B), the third party (T) sends the first party's digital signature (sign_A) to the second party (B) and sends the second party's digital signature (sign_B) to the first party (A).

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A Method of Exchanging Digital Data

The invention relates to digital data exchange and electronic commerce, and in particular, to a method of fair and efficient exchange of digital data between potential distrustful parties over a digital communication channel.

An important issue in information processing and electronic commerce is how to exchange non-repudiation information between two potentially distrustful parties in a secure and fair manner. An example of this is the electronic contract signing problem where two parties are physically apart and negotiate a contract in the form of digital document over a communication network. The contract is considered legally binding if the two parties have each other's digital signatures on the digital document. The two parties need to execute a fair exchange protocol to obtain each other's digital signatures. Other applications of fair exchange protocols include certified electronic mail delivery and electronic auctioning over internet.

Fair exchange has been studied for some time in the context of "simultaneous secret exchange" or "gradual secret releasing", see for examples, S. Even, O. Goldreich, and A. Lempel, "A randomized protocol for signing contracts", Communications of the ACM, vol. 28, pp. 637-647, June 1985; also see T. Okamoto and K. Ohta, "How to simultaneously exchange secrets by general assumptions", Proceedings of the 2nd ACM Conference on Computer

and Communications Security, pp. 184-192, Fairfax, Virginia, November 1994. In simultaneous secret exchange schemes, it is assumed that two parties A and B each possess a secret a and b, respectively, where a and b are n bit strings. Further it is assumed that both secrets represent some value to the other party and that they are willing to trade the secrets with each other. A simultaneous secret exchange process is typically carried out as following. First, A and B exchange f(a) and g(b) for some predefined functions f() and g(), with the property that A can not get b from g(b) and B can not recover a from f(a). Then, A and B release a and b bit-by-bit. For such a protocol to be useful, it must satisfy the following two requirements: correctness -- the correctness of each bit given must be checked by each receiver to ensure that his/her secret has not being traded for garbage; and fairness -- the computational effort required from the parties to obtain each other's remaining secret should be approximately equal at any stage during the execution of the protocol. Note that the above fairness definition based on equal computational complexity makes sense only if the two parties have equal computing power, an often unrealistic and undesirable assumption. Another drawback of the above scheme is that the execution of the scheme requires many rounds of interactions between the two parties.

The other approach in fair exchange is using an on-line trusted third party (TTP), see for examples, J. Zhou and D. Gollmann, "A fair non-repudiation protocol", Proceedings of the 1996 IEEE

Symposium on Security and Privacy", IEEE Computer Press, pp. 55-61, Oakland, CA; R. H. Deng, L. Gong, A. A. Lazar, and W. Wang, "Practical protocols for certified electronic mail", Journal of Network and Systems Management, vil. 4, no. 3, pp. 279-297, 1996. In on-line TTP based protocols, the TTP acts as a middleman. A and B forward their messages/signatures to the TTP. The TTP first checks the validity of the received signatures and then relays them to the respective parties. The major drawback of this approach is that the TTP is always involved in the exchange even if the parties are honest and no fault occurs; therefore, the on-line TTP is both a computational bottleneck and a communications bottleneck. To avoid such bottlenecks, a more novel approach is to use protocols with an off-line TTP. That is, the TTP does not get involved in the normal or exceptionless case, it gets involved only in the presence of faults or in the case of dishonest parties who do not follow the protocols.

To our knowledge, the only fair exchange protocols using off-line TTP are given by N. Asokan, M. Schunter, and M. Waidner, "Optimistic protocols for fair exchange", Proceedings of the 4th ACM Conference on Computer and Communications Security, Zurich, April 1997. However, these protocols achieve fairness only if the TTP can undo a transfer of an item or it is able to produce a replacement for it; otherwise, a misbehaving party may get other party's data and refuse to send his data to the other party. When this happens, all the TTP can do in the above mentioned protocols is to issue affidavits

attesting to what happened during the exchange. However, such affidavits may be useless in the internet environment where the cheating party may disappeared easily and the damage to the honest party may not be revocable.

In accordance with the present invention, a method of exchanging digital data between a first party, having a unique first digital data, and a second party, having a unique second digital data, over a communication link, the method comprising the steps of:

(a) the first party encrypting the first digital data and generating an authentication certificate, the authentication certificate authenticating that the encrypted first digital data is an encryption of the first digital data, and sending the encrypted first digital data and the authentication certificate to the second party;

(b) the second party verifying that the encrypted first digital data is an encryption of the first digital data using the authentication certificate, and the second party sending the second digital data to the first party if the verification is positive;

(c) the first party verifying that the second digital data is valid, and if the verification is positive the first party accepts the second digital data and sends the unencrypted first digital data to the second party;

(d) the second party verifying that the first digital data is valid, and if the verification is positive, the second party accepts the second digital data; otherwise, the second entity sends the encrypted first digital data and the second digital data to a third party, third party having a decryption key to decrypt the encrypted first digital data; and

(e) the third party decrypting the encrypted first digital data to obtain the first digital data, verifying that the first and the second digital data are valid and, if both the first and the second digital data are verified as valid, sending the first digital data to the second party and the second digital data to the first party.

The invention provides a method of exchanging digital data between distrustful parties over a communication link, and has the advantages of 1) using an off-line trusted third party (TTP), i.e., TTP does not take part in the exchange unless one of the exchanging parties behaves improperly; 2) being efficient in communications, only three message exchanges are required in the normal situation; and 3) achieving fairness, i.e., either A and B obtain each other's data or no party receives anything useful, and no loss is incurred to a party no matter how maliciously the other party behaves during the exchange.

Fairness is only achieved if the exchange protocol possesses a so called loss-preventing property. Loss-preventing means that

no loss is incurred to a party no matter how improperly the other party performs. More specifically, an exchange protocol achieves true fairness if it guarantees that either both parties obtain each other's signatures or none of them get anything. The exchange systems presented in this invention are the first which achieve true fairness with off-line TTP.

A new cryptographic primitive, called the Certificate of Encrypted Message Being a Signature (CEMBS) is also invented here. The CEMBS is used to prove that an encrypted message is a certain party's signature on a file without revealing the actual signature.

Examples of a method of exchanging digital data in accordance with the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows the steps of fair exchange digital signatures on a common file;

Figure 2 shows the steps of fair exchange of a file and a digital signature on a one-way hash of the file;

Figure 3 illustrates the flow diagram of the first Signature-Ciphertext-CEMBS-Generation Program (SCCGP) used in the preferred embodiment of the present invention; and,

Figure 4 shows the flow diagram of the second Signature-Ciphertext-CEMBS-Generation Program (SCCGP) used in the preferred embodiment of the present invention.

The parties involved in the protocols and some of the notations used in the description of the examples are as follows.

Notations related to public key encryption scheme

P : a public key encryption scheme

Pencr : encryption algorithm of P

Pdecr : decryption algorithm of P

PK : a public key in P

SK : the private key corresponding to PK

Pencr(PK, m) : encryption output (i. e., ciphertext) of a plaintext m using PK

Pdecr(SK, c) : decryption output (i. e., plaintext) of a ciphertext c using SK

Notations related to digital signature schemes

S : a digital signature scheme

Ssign : signing algorithm of S

Sveri : verifying algorithm of S

sk : a private (or signing) key in S

pk : the public (or verifying) key corresponding to sk

Ssign(sk, m) : signature on a plaintext m under private key sk

Sveri(pk, sign, m) : verification of a signature sign on a message m using public key pk; it outputs

yes if the signature is valid and no

otherwise

Mathematics notations

a^b :a raised to the bth power

a||b : the concatenation of a and b

Zp : the set of p integers {0, 1, 2, ..., p-2, p -1}

Zp* : the subset of integers in Zp which are relatively prime to p

There are three generic parties in a fair-exchange system,

Parties involved

A :a party involved in a fair exchange. It has a pair of public/private keys pkA and skA used for signature verification and generation, respectively.

B :a party involved in a fair exchange. It has a pair of public/private keys pkB and skB used for signature verification and generation, respectively.

T :an off-line trusted third party (TTP). It has a pair of public/private keys PKT and SKT used for encryption and decryption, respectively

Remarks: the above keys of each parties are long term keys. There must be a secure binding between a party's identity and its public key. Such a binding may be in the form of a public key certificate issued by a certification authority. For references on public key encryption schemes, digital signature

schemes, encryption and decryption and one-way hash functions, public key certificates, see D. E. R. Denning, Cryptography and Data Security, Addition-Wesley, Reading, MA, 1983; W. Stallings, Network and Internetworks Security - Principles and Practice, Prentice Hall, Englewood Cliffs, NJ, 1995; and C. Kaufman, R. Perlman and M. Speciner, Network Security - Private Communication in a Public World, PTR Prentice Hall, Englewood Cliffs, NJ, 1995.

We will describe three protocols for fair exchange of digital data between distrustful parties A and B with an off-line trusted third party T. In all the protocols, we implement a new cryptographic mechanism called Certificate of Encrypted Message Being a Signature (CEMBS). A CEMBS is generated by the party who initiates a fair exchange to prove to others, in particular the other party, that an encrypted message is a certain party's signature on a known file while without revealing the signature. Let PKX/SKX be party X's public/private key pair in a public key encryption scheme and pkY/skY be party Y's public/private key pair in a digital signature scheme. Let sign_Y = Ssign(skY, M) be Y's signature on a file M under skY and C_X = Pencr(PKX, sign_Y) be the ciphertext of the encrypted signature sign_Y under X's public key PKX. Party Y can generate a CEMBS, denoted as Cert_Y_X, to prove that C_X is indeed the encryption (under PKX) of the signature sign_Y on M while without disclosing the signature. The Cert_Y_X can be verified by anyone using a public verification algorithm Veri, which on inputs Cert_Y_X, C_X, M, PKX, and pkY, output "yes" or "no".

That is, Veri(Cert_Y_X, C_X, M, PKX, pkY) = yes or no. If it is yes, then we must have C_X =Pencr(PKX, sign_Y) and Sveri(pkY, sign_Y, M) = yes for some sign_Y. In other words, if we decrypt C_X using SKX, the result is the signature on M under the key skY. It is impossible (computationally hard) to generate a Cert_Y_X such that Veri(Cert_Y_X, C_X, M, PKX, pkY) = yes without C_X = Pencr(PKX, sign_Y) and Sveri(pkY, sign_Y, M) = yes holding true for some sign_Y.

The CEMBS can be realized on cryptosystems with P = ElGamal public key encryption scheme and S = DSA-like digital signature scheme. It can also be realized on cryptosystems with P = ElGamal public key encryption scheme and S = Guillou-Quisquater digital signature scheme. Procedures on the realization and verification of CEMBA will be shown later.

In all the fair exchange protocols disclosed here we assume that 1) the parties A, B, and T have agreed on the public key encryption scheme P and the digital signature scheme S; 2) all parties know each others public keys via authenticated manners; 3) the communication links between all the parties are reliable and are confidentiality and integrity protected where necessary; and 4) party A is the one who initiates a fair exchange session.

1. Protocol 1 - Fair Exchange of Digital Signatures on A Common File

It is assumed that A and B have agreed on a common file (such as a digital contract document) M. Referring to Figure 1, the steps for A and B to exchange their digital signatures sign_A and sign_B on M are:

a. Party A, in step 100 using a Signature-Ciphertext-CEMBS-Generation Program (SCCGP), computes its signature sign_A = Ssign(skA, M) on the file M, the ciphertext C_T = Pencr(PKT, sign_A) on sign_A under T's public key PKT, and the CEMBS Cert_A_T which is used to prove that C_T is a ciphertext of sign_A without disclosing the signature. A sends MSG1 = (C_T, Cert_A_T) to B.

b. Party B, upon receiving MSG1 in step 120, checks whether Veri(Cert_A_T, C_T, M, PKT, pkA) = yes in step 140. If the answer is "no", B does nothing or sends an alert signal to A in step 160; if it is "yes", B computes and sends his signature sign_B = S_sign(skB, M) as MSG2 to A in step 180.

c. In step 200, A checks to see if it receives MSG2 and if so, checks whether Sveri(pkB, sign_B, M) = yes. If A does not receive MSG2 or the received sign_B is not valid, A does nothing or sets up an alert signal to itself and B in step 220. If sign_B is valid, A accepts it and sends sign_A as MSG3 to B in step 240. At this point, A considers the fair exchange completed.

d. In step 260, B checks to see if it receives MSG3 and if

so, checks whether Sveri(pkA, sign_A, M) = yes. If B receives MSG3 and sign_A is valid, it accepts sign_A in step 280. At this point, B considers the fair exchange completed. If B does not receive MSG3 or the received sign_A is not valid, B sends M, C_T and sign_B as MSG4 to T in step 300.

e. Upon receiving MSG4 in step 320, T in step 340 first checks sign_B using B's public key pkB to make sure that it is B's signature on M. If sign_B is correct, T decrypts C_T using its private key SKT to get sign_A and then checks whether it is A's signature on M using A's public key pkA. If both sign_A and sign_B are valid, T sends sign_A in MSG5 to B and sign_B in MSG6 to A in step 360. On the other hand, if either sign_B or sign_A is incorrect, T does nothing or send an alert signal to B in step 380.

f. Upon receiving MSG5 in step 400, B accepts sign_A and terminates the session.

g. Upon receiving MSG6 in step 420, A accepts sign_B if it has not been accepted in step 240; otherwise, A discards MSG6.

It is apparent that if A and B both behave properly, they will obtain each other's signatures without any involvement of T. Now consider what happens if B performs improperly. B has two chances to perform improperly. The first one is in step 180 where B may send A an incorrect sign_B, but A can detect this in step 200 and refuse to give sign_A to B. The second chance

is right after step 120, B stops the protocol, goes to T, and asks it to decrypt C_T in order to get sign_A while without giving sign_B to A; however, according to step 340, T will send sign_A to B only if B gives correct sign_B to T. In that case, T will forward sign_B to A in step 360. Finally, let us consider what happens if A performs improperly. A may perform improperly in step 100 by giving B incorrect (C_T, Cert_A_T). However, B will detect this and stops the session. If A sends "C_T, Cert_A_T" to B such that Veri(Cert_A_T, C_T, M, PKT, pkA) = yes, then, C_T must be the ciphertext (under PKT) of A's signature on M according to the definition of CEMBS. In this case, if A performs improperly later in step 240, such as sending B an incorrect sign_A or not sending anything, B can ask T to open C_T and get A's signature on M.

2. Protocol 2 - Fair Exchange of Digital Signatures on Different Files

Here we assume that A and B have agreed on two files M_A and M_B. The process for A and B to exchange their digital signatures on M_A and M_B, respectively, are identical to those in Protocol 1 except that 1) A's signature is on "M_A||h(M_B)" and B's signature is on "M_B||h(M_A)", i. e., sign_A = Ssign(skA, M_A||h(M_B)) and sign_B = Ssign(skB, M_B||h(M_A)), where h() is a one-way hash function; 2) when B asks T's help in step 300, B sends M_A, M_B, C_T, and sign_B as MSG4 to T; and 3) upon receiving MSG4 in step 320, T in step 340 decrypts C_T to get sign_A and checks to see if sign_A and sign_B are

and A and B's signatures on "M_A||h(M_B)" and "M_B||h(M_A)", respectively.

3. Protocol 3 - Fair Exchange of Confidential Data and Signature

Figure 2 shows the process of exchanging a confidential message and a signature on the message between A and B. More specifically, this protocol lets A send a digital signature on a one-way hash h(M) of a file M to B in exchange for M from B. Note that A's signature is on h(M) instead of M. It is impossible for A to sign directly on M before A sees it. On the other hand, after A sees M, it may refuse to send B the signature. No protocol can solve this dilemma. To avoid A signing on h(M) but receives a message M' different from the desired M, we assume that A has means of obtaining a one-way hash of the desired message M in authenticated manners. As pointed out in M. K. Franklin and M. K. Reiter, "Fair exchange with a semi-trusted third party", Proceedings of the 4th ACM Conferences on Computer and Communications Security, pp. 1-5, April 1-4, 1997, Zurich, Switzerland, this assumption is justified in protocols and applications in which one-party is responsible for revealing the input that produces a known output, already validated as part of the protocol or application, from a one-way hash function. Examples include the S/KEY user authentication system, see N. M. Haller, "The S/KEY one-time password system", Proceedings of the Internet Society Symposium on Network and Distributed Systems, 1994, the PayWord

electronic payment scheme, see R. Rivest and A. Shamir, "PayWord and MicroMint - two simple micropayment schemes", RSA CryptoBytes, 1996, and applications of digital timestamping S. Haber and W. S. Stornetta, "How to time-stamp a digital document", Journal of Cryptology, 3(2), pp. 99-111, 1991.

The steps of the exchanges are:

a. Party A, in step 500 using a Signature-Ciphertext-CEMBS-Generation Program (SCCGP), computes its signature sign_A = Ssign(skA, h(M)) on the one-way hash of the desired message, the ciphertext C_T = Pencr(PKT, sign_A) on sign_A under T's public key PKT, and the CEMBS Cert_A_T which is used to prove that C_T is a ciphertext of sign_A without releasing the signature. A sends C_T and Cert_A_T as MSG1 to B.

b. B, upon receiving MSG1 in step 520, checks whether Veri(Cert_A_T, C_T, h(M), PKT, pkA) = yes in step 540. If the answer is "no", B does nothing or sends an alert signal to A step 560; if it is "yes", B sends M in MSG2 to A in step 580.

c. In step 600, A checks to see if it receives MSG2 = M and if so, checks whether the one-way hash of the received message matches the known h(M). If A does not receive MSG2 or M is not valid (i. e., the one-way hash of the received message does not match h(M)), A does nothing or sets up an alert signal to itself and B in step 620. If the received M is valid, A accepts it and sends sign_A in MSG3 to B in step 640. At this point, A

considers the fair exchange process completed.

d. In step 660, B checks to see if it receives MSG3 and if so, checks whether Sveri(pkA, sign_A, h(M)) = yes. If B receives MSG3 and sign_A is valid, it accepts sign_A in step 680. At this point, B considers the fair exchange process completed. If B does not receive MSG3 or the received sign_A is not valid, B sends M and C_T to T in MSG4 in step 700.

e. Upon receiving MSG4 in step 720, T in step 740 first computes h(M) of the received M, decrypts C_T using its private key SKT to get sign_A and then checks whether it is A's correct signature on h(M) using A's public key pkA. If it is, T sends sign_A in MSG5 to B and sends M in MSG6 to A in step 760. On the other hand, if sign_A is not a signature on the newly computed h(M), T does nothing or send an alert signal to B in step 780.

f. Upon receiving MSG5 in step 800, B accepts sign_A and terminates the session.

g. Upon receiving MSG6 in step 820, A accepts M if it has not been accepted in step 640; otherwise, A discards MSG6.

4. The First Embodiment of the SCCGP

Figure 3 shows the flow chart of the first embodiment of the Signature-Ciphertext-CEMBS-Generation Program (SCCGP). It is

described for a cryptosystem where P = ElGamal public key encryption scheme and S = DSA-like digital signature scheme. For references on ElGamal scheme and DSA, see T. ElGamal, "A public key cryptosystem and a signature scheme based on discrete logarithms", IEEE Transactions on Information Theory, IT-31(4):469-472, 1985 and NIST FIPS PUB 181, Digital Signature Standard, U.S. Department of Commerce/National Institute of Standards and Technology, respectively.

Let p and q be prime integers such that p = 2q +1. For security reason, we require that q - 1 have no small prime factors except 2. Let G, an element in Zp*, have order q and g be a generator of Zq*. We have

P: ElGamal public key encryption scheme on (Zq*, g)
SKT: a random element in {1, 2, ..., q-2}
PKT: g^SKT mod q
The ciphertext of m, where m is an element in Zq*, under PKT is C_T = Pencr(PKT, m) = (W, V) where W= g^w mod q for a random number w in {1, 2, ...,q-2} and V = m(PKT)^w mod q. The decryption is m = V/(W^SKT) in Zq*. Further, we have

S: a DSA-like signature scheme on (Zp*, G)
skA: an element in Zq*
pkA: G^skA mod p

Party A's signature on M under skA is Ssign(skA, M)= (r, s) where r = G^k mod p for an random element k in Zq* and s =

(h(M)+r(skA))/k mod q. Here h() is a one-way hash function. The verification Sveri(pkA, (r, s), M) is to check whether r^s = (G^h(M))(pkA^r) mod p.

CEMBS in the cryptosystem described above can be realized through Stadler's PEDLDLL (Proof of Equivalence of Discrete Logarithm to Discrete LogLogarithm), see M. Stadler, "Publicly verifiable secret sharing", Proceedings of Eurocrypto'96, LNCS 1070, Springer-Verlag, pp.190-199, 1996. The PEDLDLL problem is stated as following:

Let p and q be as defined above. Let x, y and z be elements in Zq* and X and Y be elements in Zp* where the order of X is q. There exists a a in {1, 2, ..., q-2} such that y = x^a mod q and Y=X^((z^a)) mod p. A prover, who knows a, can produce a PEDLDLL certificate to prove to a verifier that indeed y = x^a mod q and Y = X^((z^a)) mod p for some a while not revealing a and z^a. Here x, y, z, X, and Y can be regarded as public values to the verifier.

The CEMBS Cert_A_T can be induced from a PEDLDLL certificate as follows. When party A encrypts the signature sign_A = (r, s) under PKT, it only encrypts s while leaves r in plain. That is, the encrypted signature is C_T = (r, Pencr(PKT, s)) where Pencr(PKT, s) = (W, VT), with W = g^w and VT = s((PKT)^w). Hence, the encrypted message is A's signature on M implies that

$r^s = (G^{h(M)})(pkA^r) \bmod p,$

$W = g^w \bmod q,$

$VT = s(PKT^w) \bmod q$

It is straightforward to see that the above are equivalent to

$1/W = g^{(-w)} \bmod q,$

$(G^{h(M)})(pkA^r) = (r^{VT})^{(PKT^{(-w)})} \bmod p,$

Note that here W, g, G, h(M), pkA, r, VT, and PKT are all public values. Hence, proof of the last two equations is equivalent to the PEDLDLL if we let a = -w, x = g, y = 1/W, z = PKT, X = r^VT, and Y = (G^h(M))(pkA^r). Therefore, generation of CEMBS is equivalent to generation of a PEDLDLL certificate.

Referring to Figure 3, the steps of the first embodiment of the SCCGP invention are:

a. After reading the message M from step 1000, compute party A's signature sign_A = Ssign(skA, M) = (r, s) on M under private key skA based on the DSA-like signature scheme in step 1020, where r = G^k mod p for a value k selected randomly from Zq* and s = (h(M) + r(skA))/k mod q.

b. Encrypt s under T's public key PKT to get Pencr(PKT, s) = (W, VT) using the ElGamal public key encryption scheme in step 1040, where W = g^w mod q, VT = s(PKT^w) mod q, and w being a number randomly selected from {1, 2, ..., q-2}.

c. Generate CEMBS Cert_A_T in step 1060. The Cert_A_T is the PEDLDLL certificate with a = -w, x = g, y = 1/W, z = PKT, X = r^VT, and Y = (G^h(M))(pkA^r). The PEDLDLL is generated as follows. For i = 1, 2, ..., L, randomly select wi from {1, 2, ..., q-2}, compute txi = x^wi mod q, tXi = X^(z^wi) mod p, and c = H(x||y||z||X||Y||tx1||tX1||tx2||tX2||...||txL||tXL), where H() is a one-way hash function with L output bits c = c1c2...cL, ci = 0 or 1. Finally, compute R = (r1, r2, ..., rL) where ri = wi -a(ci) mod q-1, i = 1, 2, ..., L. The PEDLDLL (or equivalently Cert_A_T) is (R, c).

d. Output sign_A, C_T = (r, Pencr(PKT, s)), and Cert_A_T in step 1080.

The verification of the PEDLDLL/Cert_A_T is to check whether c = H(x||y||z||X||Y||u1||U1||u2||U2||...||uL||UL) holds true, where ui = (x^ri)(y^ci) mod q, Ui = X^(z^ri) mod p if ci = 0 or Y^(z^ri) mod p if ci = 1, for i = 1, 2, ..., L, and where x = g, y = 1/W, z = PKT, X = r^VT, and Y = (G^h(M))(pkA^r).

5. The Second Embodiment of the SCCGP

Figure 4 shows the flow chart of the second embodiment of the Signature-Ciphertext-CEMBS-Generation Program (SCCGP) of the present invention. It is described for a cryptosystem with P = ElGamal public key encryption schene and S = Guillou-Quisquater digital signature scheme. For reference on the Guillou-Quisquater digital signature scheme, see L. C.

Guillou, M. Ugon, and J.-J. Quisquater, "The Smart Card: A Standardized Security Device Dedicated to Public Cryptology", in Contemporary Cryptology - The Science of Information Integrity, edited by G. J. Simmons, IEEE Press, New York, pp.561-614, 1992.

The cryptosystem requires a trusted authorized center AC to create system parameters. AC chooses two primes R and Q where R = 2p'q+1, Q = 2pq+1 for primes p', p and q, sets n = RQ and chooses an element g in Zn* such that it has order q. Next, AC randomly chooses a large number v co-prime to (R-1)(Q-1) and publishes system parameters n, g, q, v. R and Q can be destroyed and AC may cease to exist after this system initialization.

The cryptosystem uses the ElGamal PKC on (Zn*, g) and the Guillou-Quisquater digital signature scheme on (Zn*,v). Specifically, we have

P: ElGamal system on (Zn*, g)
SKT: randomly selected from {1, 2, ..., q-2}
PKT: g^SKT mod n

The ciphertext of m, an element in Zn*, under PKT is Pencr(PKT, m) = (W, V), where W= g^w mod n for a random w in {1, 2, ..., q-1} and V = m(PKT)^w mod n. The decryption is m = V/W^SKT mod n. Further, we have

S: Guillou-Quisquater signature scheme on (Zn*, v)

skA: randomly selected from Zn*

pkA: J such that J(skA)^v = 1 mod n

To sign a message M, party A randomly chooses r, sets T = r^v mod n, computes d = h(M||T) and D = r(skA^d) mod n. The signature is sign_A = (d, D). The verification of the signature is to check whether d = h(M||(D^v)(pkA^d) mod n) holds.

Referring the Figure 4, the steps of the SCCGP program are:

a. Upon imputing the message M to be signed in step 1200, compute party A's signature sign_A = (d, D) on M under private key skA in step 1220, where T = r^v mod n with r being a random number, d = h(M||T) and D = r(skA^d) mod n.

b. Encrypt D under T's public key PKT to get C_T = Pencr(PKT, D) = (W, VT) in step 1240, where W = g^w mod n, VT = D(PKT^w) mod n, and w being a number randomly selected from Zn*.

c. Generate Cert_A_T = (r, c, V, d) in step 1260, where d is from step 1200, V = D^v mod n, and (r, c) are calculated as follows:
randomly choose u from {1, 2, ..., q-1}, compute a = g^u mod n and A = (PKT^v)^u mod n. Then compute c = H(g||W|| PKT^v||(VT^v)/V||a||A) and r = u-cw mod q and where H() is a one-way hash function.

d. Output sign_A, C_T, and Cert_A_T in step 1280.

Note that verification of Cert_A_T is to check whether c= H(g||W||PKT^v||(VT^v)/V||(g^r)(W^c)||((PKT^v)^r)((VT^v/V)^c) holds true.

Claims

1. A method of exchanging digital data between a first party having a unique first digital data and a second party having a unique second digital data over a communication link, the method comprising the steps of:

(a) the first party encrypting the first digital data and generating an authentication certificate, the authentication certificate authenticating that the encrypted first digital data is an encryption of the first digital data, and sending the encrypted first digital data and the authentication certificate to the second party;

(b) the second party verifying that the encrypted first digital data is an encryption of the first digital data using the authentication certificate, and the second party sending the second digital data to the first party if the verification is positive;

(c) the first party verifying that the second digital data is valid, and if the verification is positive the first party accepts the second digital data and sends the unencrypted first digital data to the second party;

(d) the second party verifying that the first digital data is valid, and if the verification is positive, the second party accepts the first digital data; otherwise, the second party

sends the encrypted first digital data and the second digital data to a third party, third party having a decryption key to decrypt the encrypted first digital data; and

(e) the third party decrypting the encrypted first digital data to obtain the first digital data, verifying that the first and the second digital data are valid and, if both the first and the second digital data are verified as valid, sending the first digital data to the second party and the second digital data to the first party.

2. A method according to claim 1, in which the first and second digital data are on files M_A and M_B respectively, the first party in step (a) encrypting the first digital data on a concatenation of file M_A and a one-way hash of file M_B; and the second party in step(b), if the verification is positive, encrypting the second digital data on a concatenation of file M_B and a one-way hash of file M_A.

3. A method according to claim 1 or claim 2, wherein the first and second digital data are digital signatures belonging to the first and second party, respectively.

4. A method according to claim 1, wherein the second digital data is a secret file M which the first party wishes to receive from the second party in exchange for the first digital data.

5. A method according to any of the preceding claims, wherein

the first party has a pair of public/private keys in a first digital signature scheme; the second party has a pair of public/private keys in a second digital signature scheme; and the third party has a pair of public/private keys in a public key encryption scheme.

6. A method according to claim 5, wherein the digital signature schemes are discrete logarithm based schemes; and the public key encryption scheme is a discrete logarithm based scheme.

7. A method according to claim 5, wherein the digital signature schemes are Guillou-Quisquater type digital signature schemes; and the public key encryption scheme is a discrete logarithm based scheme.

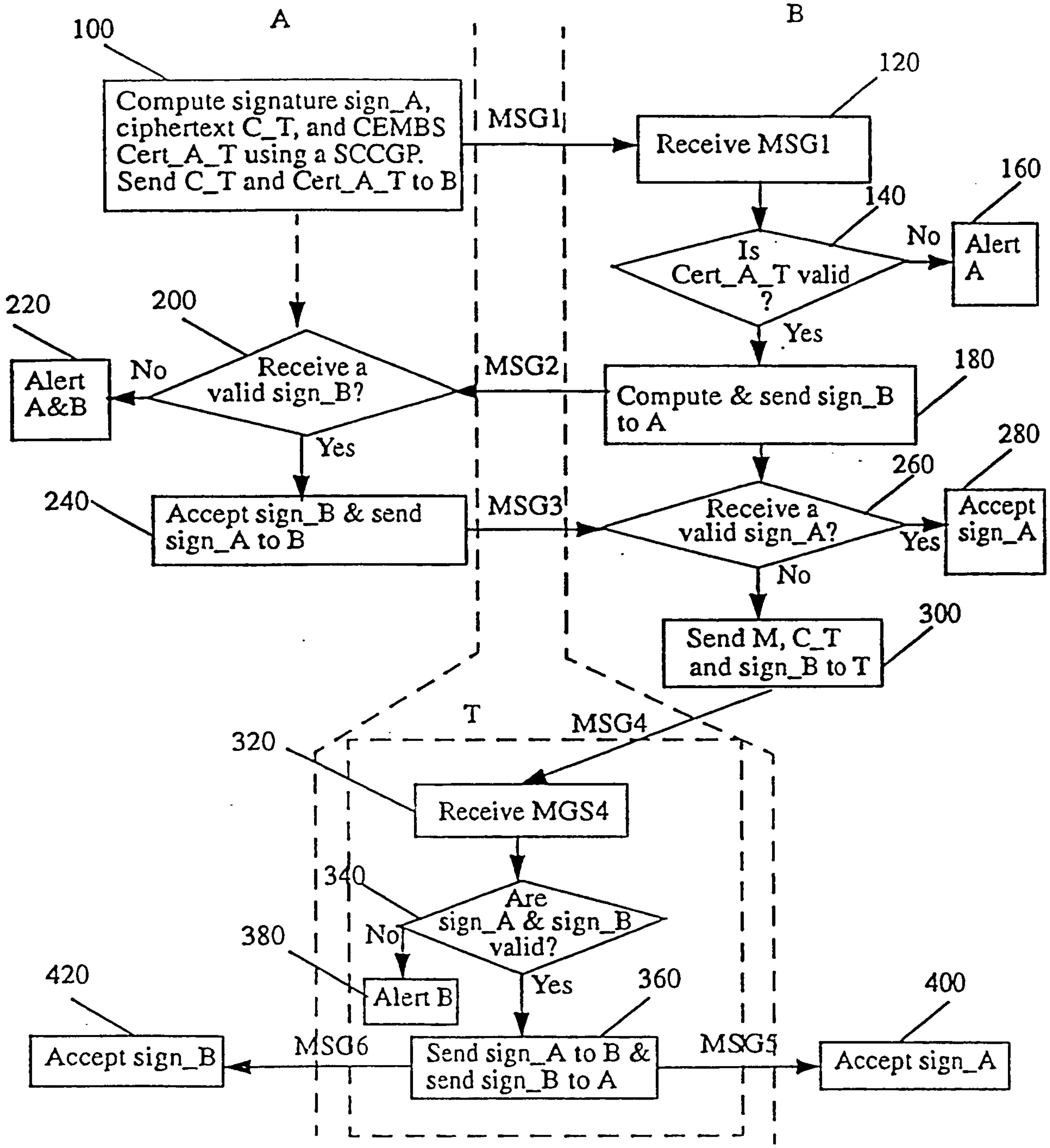
A
B
100
Compute signature sign_A, ciphertext C_T, and CEMBS Cert_A_T using a SCCGP. Send C_T and Cert_A_T to B
MSG1
120
Receive MSG1
140
Is Cert_A_T valid ?
No
160
Alert A
Yes
220
200
Alert A&B
No
Receive a valid sign_B?
MSG2
180
Compute & send sign_B to A
Yes
240
Accept sign_B & send sign_A to B
MSG3
260
Receive a valid sign_A?
Yes
280
Accept sign_A
No
300
Send M, C_T and sign_B to T
T
MSG4
320
Receive MGS4
340
Are sign_A & sign_B valid?
No
380
Alert B
Yes
360
420
Accept sign_B
MSG6
Send sign_A to B & send sign_B to A
MSG5
400
Accept sign_A

Figure 1

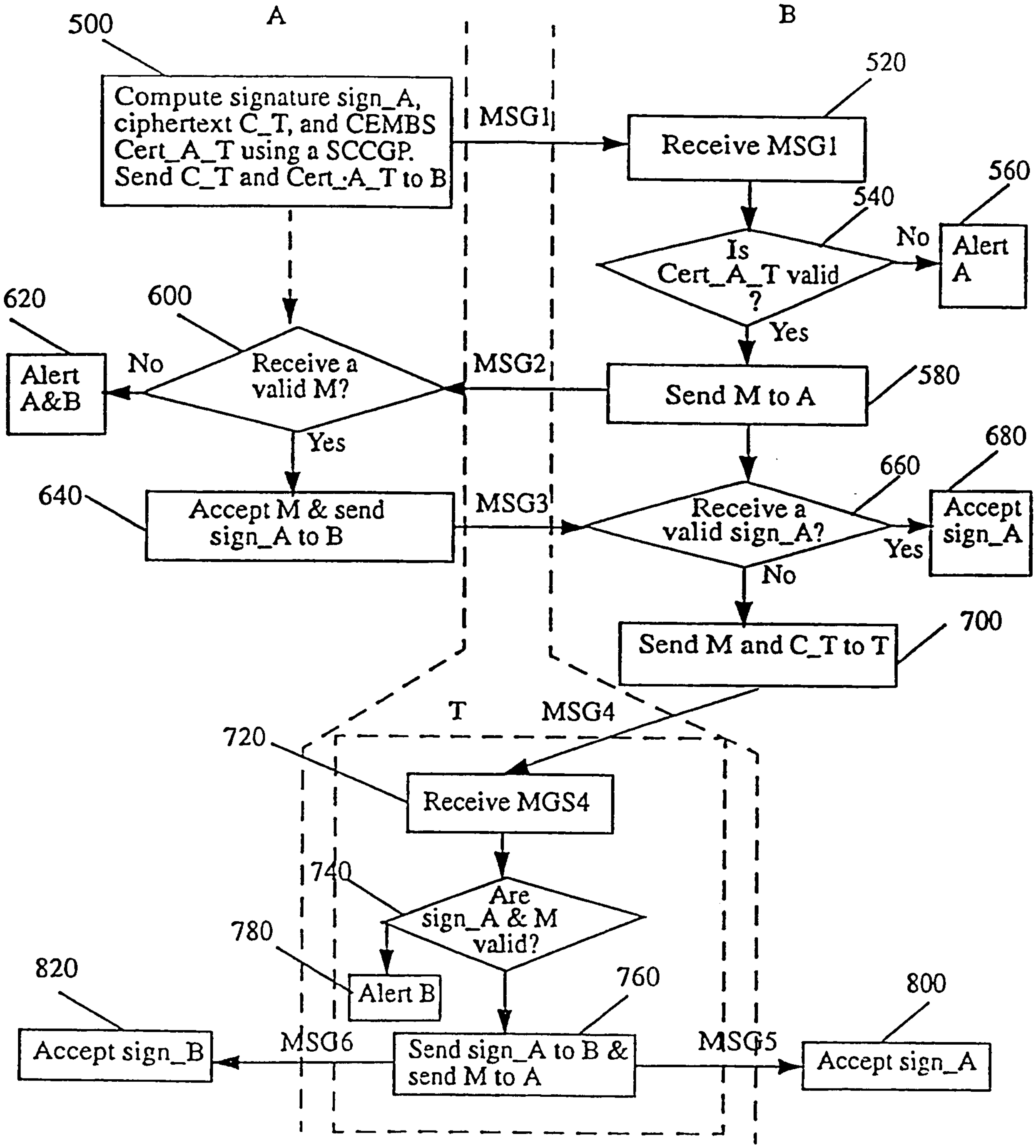
A
B
500
Compute signature sign_A, ciphertext C_T, and CEMBS Cert_A_T using a SCCGP. Send C_T and Cert_A_T to B
MSG1
520
Receive MSG1
540
Is Cert_A_T valid ?
No
560
Alert A
Yes
620
600
Alert A&B
No
Receive a valid M?
MSG2
Send M to A
580
Yes
640
Accept M & send sign_A to B
MSG3
660
Receive a valid sign_A?
Yes
680
Accept sign_A
No
Send M and C_T to T
700
T
MSG4
720
Receive MGS4
740
Are sign_A & M valid?
780
Alert B
760
820
Accept sign_B
MSG6
Send sign_A to B & send M to A
MSG5
800
Accept sign_A

Figure 2

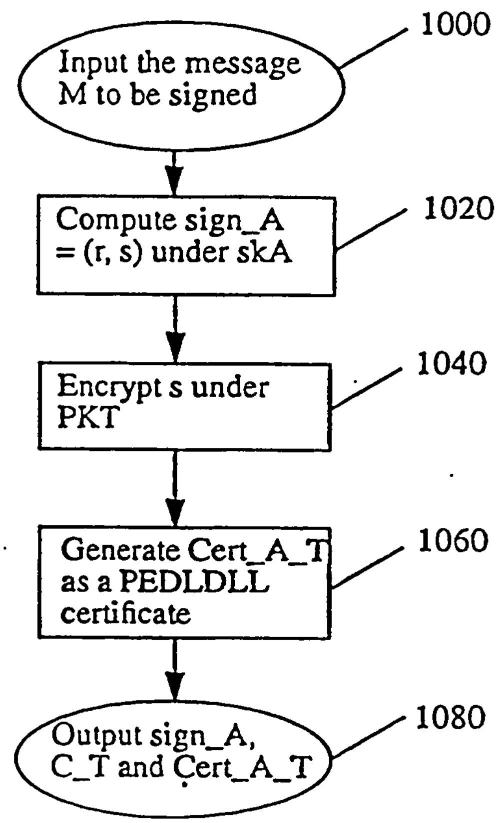
1000
Input the message M to be signed
1020
Compute sign_A = (r, s) under skA
1040
Encrypt s under PKT
1060
Generate Cert_A_T as a PEDLDLL certificate
1080
Output sign_A, C_T and Cert_A_T

Figure 3

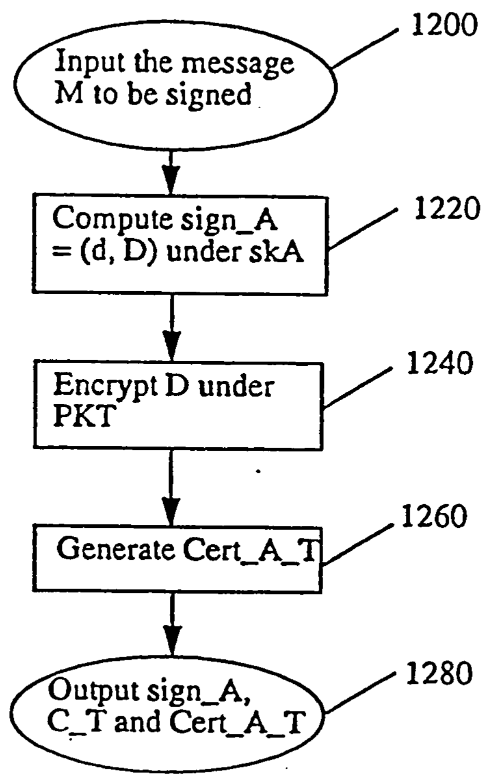
Input the message M to be signed
1200
Compute sign_A = (d, D) under skA
1220
Encrypt D under PKT
1240
Generate Cert_A_T
1260
Output sign_A, C_T and Cert_A_T
1280

Figure 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG 98/00020

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H 04 L 9/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H 04 L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 328 232 A2 (FISCHER, ADDISON M.) 16 August 1989 (16.08.89), abstract; page 3, line 30 - page 4, line 53; page 5, line 22 - page 9, line 35; fig. 1-3.	1,3,5
A	WO 96/02 993 A2 (BANKERS TRUST COMPANY) 01 February 1996 (01.02.96), abstract; page 1, line 2 - page 10, line 8.	1,3,5
A	EP 0 578 059 A1 (THOMSON CONSUMER ELECTRONICS S.A.) 12 January 1994 (12.01.94), abstract; page 4, lines 11-28.	1,3,5,7
A	WO 93/03 562 A1 (UNITED STATES GOVERNMENT) 18 February 1993 (18.02.93), abstract; page 1, line 6 - page 3, line 16; page 11, line 7 - page 15, line 18; fig. 1,2.	1,3,5

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 January 1999 (29.01.99)	04 February 1999 (04.02.99)

Name and mailing address of the ISA/	Authorized officer
Austrian Patent Office Kohlmarkt 8-10; A-1014 Vienna Facsimile No. 1/53424/535	Hajos Telephone No. 1/53424/410

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SG 98/00020

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		AU A1 25124/88	07-09-89
		AU B2 601935	20-09-90
		CA A1 1331213	02-08-94
		DE C0 68922422	08-06-95
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		NO A 970084	10-03-97
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EP A1 578059	12-01-94	none	
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		BR A 9206315	04-04-95
		CA AA 2111572	18-02-93
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		HU A0 9400228	30-05-94
		HU A2 68148	29-05-95
		JP T2 7502346	09-03-95
		NL A 9220020	01-06-94
		NO A 940258	25-01-94
		NO A0 940258	25-01-94
		SE A0 9400103	17-01-94
		US A 5231668	27-07-93

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG 98/00020

A. CLASSIFICATION OF SUBJECT MATTER

IPC^6: H 04 L 9/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC^6: H 04 L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 328 232 A2 (FISCHER, ADDISON M.) 16 August 1989 (16.08.89), abstract; page 3, line 30 - page 4, line 53; page 5, line 22 - page 9, line 35; fig. 1-3.	1,3,5
A	WO 96/02 993 A2 (BANKERS TRUST COMPANY) 01 February 1996 (01.02.96), abstract; page 1, line 2 - page 10, line 8.	1,3,5
A	EP 0 578 059 A1 (THOMSON CONSUMER ELECTRONICS S.A.) 12 January 1994 (12.01.94), abstract; page 4, lines 11-28.	1,3,5,7
A	WO 93/03 562 A1 (UNITED STATES GOVERNMENT) 18 February 1993 (18.02.93), abstract; page 1, line 6 - page 3, line 16; page 11, line 7 - page 15, line 18; fig. 1,2.	1,3,5

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 January 1999 (29.01.99)	04 February 1999 (04.02.99)
Name and mailing address of the ISA/ Austrian Patent Office Kohlmarkt 8-10; A-1014 Vienna Facsimile No. 1/53424/535	Authorized officer Hajos Telephone No. 1/53424/410

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SG 98/00020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP A2 328232	16-08-89	AT E 122190	15-05-95
		AU A1 25124/88	07-09-89
		AU B2 601935	20-09-90
		CA A1 1331213	02-08-94
		DE C0 68922422	08-06-95
		DE T2 68922422	07-09-95
		EP A3 328232	12-12-90
		EP B1 328232	03-05-95
		ES T3 2071651	01-07-95
		US A 4868877	19-09-89
		US A 5005200	02-04-91
WO A2 9602993	01-02-96	AU A1 37156/95	16-02-96
		AU B2 698454	29-10-98
		CA AA 2194475	01-02-96
		CZ A3 9700115	17-09-97
		EP A2 771499	07-05-97
		JP T2 10504150	14-04-98
		NO A0 970084	09-01-97
		NO A 970084	10-03-97
		WO A3 9602993	07-03-96
		US A 5659616	19-08-97
		IL A0 118828	31-10-96
		BR A 9508716	21-10-97
EP A1 578059	12-01-94	none	
WO A1 9303562	18-02-93	AU A1 23944/92	02-03-93
		BR A 9206315	04-04-95
		CA AA 2111572	18-02-93
		EP A1 596945	18-05-94
		FI A 940364	25-01-94
		FI A0 940364	25-01-94
		HU A0 9400228	30-05-94
		HU A2 68148	29-05-95
		JP T2 7502346	09-03-95
		NL A 9220020	01-06-94
		NO A 940258	25-01-94
		NO A0 940258	25-01-94
		SE A0 9400103	17-01-94
		US A 5231668	27-07-93

17

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PATENT COOPERATION TREA

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference FP 1046	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/SG 98/00020	International filing date (*day/month/year*) 18 March 1998 (18.03.98)	Priority Date (*day/month/year*)
International Patent Classification (IPC) or national classification and IPC IPC^6: H 04 L 9/32		
Applicant Institute of Systems and Science et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examination Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of ______ sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☒ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
31 August 1999 (31.08.99)	27 December 1999 (27.12.99)
Name and mailing address of the IPEA/AT Austrian Patent Office Kohlmarkt 8-10 A-1014 Vienna Facsimile No. 1/53424/200	Authorized officer Hajos Telephone No. 1/53424/410

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SG 98/00020

I. Basis of the report

1. With regard to the **elements** of the international application:*

☒ the international application as originally filed

☐ the description:
pages ______________________, as originally filed
pages ______________________, filed with the demand
pages ______________________, filed with the letter of ______________.

☐ the claims:
pages ______________________, as originally filed
pages ______________________, as amended (together with any statement) under Article 19
pages ______________________, filed with the demand
pages ______________________, filed with the letter of ______________.

☐ the drawings:
pages ______________________, as originally filed
pages ______________________, filed with the demand
pages ______________________, filed with the letter of ______________.

☐ the sequence listing part of the description:
pages ______________________, as originally filed
pages ______________________, filed with the demand
pages ______________________, filed with the letter of ______________.

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language ______________ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages ______________.

☐ the claims, Nos. ______________.

☐ the drawings, sheets/fig ______________.

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as „originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

☐ restricted the claims.

☐ paid additional fees.

☐ paid additional fees under protest.

☐ neither restricted nor paid additional fees.

2. ☐ This Authority found that the requirements of unity of invention is not complied with and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirements of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

☒ complied with.

☐ not complied with for the following reasons:

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

☐ all parts.

☐ the parts relating to claims Nos.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SG 98/00020

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Citations and explanations

The cited documents show the use of digital signatures in public key cryptographic systems for verifying the integrity and origin of digital messages. The digital signature algorithms may also be used to prove to a third party that the message was signed by the actual originator.
However none of the cited documents disclose the relevant feature of claim 1 that the third party is decrypting the encrypted first digital data to obtain the first digital data, verifying that the first and the second digital data are valid and, if both the first and the second digital data are verified as valid, sending the first digital data to the second party and the second digital data to the first party.

Therefore, the subject-matter of claim 1 and the dependent claims 2-7 can be considered novel and involving an inventive step.

Industrial applicability is given for all claims.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SG 98/00020

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-7	YES
	Claims		NO
Inventive step (IS)	Claims	1-7	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-7	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

The following documents are cited in the Search Report:

EP 0 328 232 A2
WO 96/02993 A2
EP 0 578 059 A1
WO 93/03562 A1

EP 0 328 232 A2 describes a public key cryptographic system with digital signature certification which authenticates the identity of the public key holder. A hierarchy of nested certifications and signatures are employed which indicate the authority and responsability levels of the individual whose signature is being certified. Countersignature and joint signature requirements are referenced in each digital certification to permit business transactions to take place electronically.

WO 96/02993 A2 discloses a system for securely using digital signatures in a public key cryptographic system that alows security policy and authorization requirements. Each user is associated with a pair of keys, namely a public key and a private key. The digital signatures are formed using encryption algorithms. These digital signatures provide origin authentification, because only the holder of the key used for validation of the signature could have signed the message and non-repudiation, as irrevocable proof to a third party that only the signer could have created the signature.
EP 0 578 059 A1 shows Guillou-Quisquater type digital signature schemes.
WO 93/03562 A1 describes digital signature algorithms for verifying the integrity and the origin of a message. To use the digital signature algorithm effectively, means of associating a public and a private key pair with each signer are provided. These known digital signature algorithms may also be used to prove to a third party that the message was signed by the actual originator.